LEEDS PHILOSOPHIC AND LITERARY SOCIETY
CANCELLED.

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OF THE

ROYAL ASTRONOMICAL SOCIETY.

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Sir R. S. BALL, LL.D., F.R.S., President, in the Chair.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Captain E. J. Griffin, Commander of U.S.S. Co.'s S. S. *Moor*, Lieutenant R.N.R. (proposed by Captain D. Forbes) ;

J. Nevil Maskelyne, 88 Trinity Road, Upper Tooting, S.W. (proposed by E. W. Maunder) ;

Ambrose Swasey, Cleveland, Ohio, U S.A. (proposed by Sir R. S. Ball) ;

John Vaughan, Sub-Lieutenant R.N.R., Commander, China Navigation Company, Shanghai, and 42 Aubert Park, Highbury, London, N. (proposed by Thomas Mackenzie) ;

Thomas Emley Young, B.A., President of the Institute of Actuaries, 108 Evering Road, Stoke Newington, London (proposed by G. F. Hardy).

One hundred and ninety-four presents were announced as having been received since the last meeting, including, amongst others :—

J. C. Adams, Scientific Papers, vol. i., presented by the Adams Memorial Committee ; A. Auwers, Fundamental Catalog für Zonenbeobachtungen am südhimmel ; A. Auwers, Tafeln zur

notation) was equal to the total quantity incident upon the object glass, viz. $\int\int d\,x\,dy$=area of object glass, where the intensity, *i.e.* the quantity of light per unit area, incident on the object glass is unity.

The incident light was regarded as coming from a *single distant point*, so that the wave front on the object glass was plane, with uniform distribution over it.

The integral was taken over the diffraction pattern nominally between the limits $-\infty$ and $+\infty$ for both ξ and η, but practically the quantity of light contributed by an element of area in the focal plane falls off very rapidly as the distance of the element from the centre of the diffraction pattern increases.

The meaning of the infinite limits is entirely different in the case which Professor Wadsworth deals with. *Each point* in the uniformly illuminated sky considered by him contributes to the illumination of the photographic plate a quantity of light which is proportional to the area of the object glass ; but *the scale of the photograph of the sky* depends on the focal length of the object glass.

The criticism and attempted explanation which Professor Wadsworth gives of practical results obtained with large and small reflectors and refractors falls to the ground. Professor Wadsworth's conclusions are incorrect.

In the *Astrophysical Journal*, vol. vi. 1897 August, p. 132, it is clear that there is discontinuity in Wadsworth's solutions. On p. 132 he arrives at the correct result that for large finite illuminated surfaces the intensity on the photographic plate is proportional to $\frac{A^2}{f^2}$. But on the following page he reaches the incorrect result that for the large sky the intensity is proportional to A^2.

On the Apparent Diurnal Motion of Stars in relation to the Adjustment of the Polar Axis of a Telescope. By C. Davidson, Royal Observatory, Greenwich.

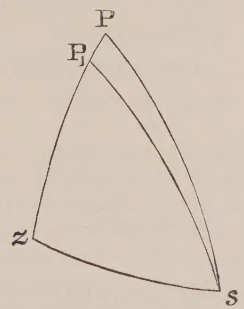
(*Communicated by W. H. M. Christie, Astronomer Royal.*)

In *Monthly Notices*, vol. 57, No. 2, Professor Rambaut has discussed the variable effect which refraction has on the apparent motion of stars, and proposes a method by which an equatorial telescope may be kept accurately pointed on a star by introducing corresponding variations into the rate of the driving clock.

In this paper, however, he does not take into account any want of adjustment of the polar axis of the telescope. If this does not point to the Pole, an additional variation in the rate of

the driving clock will be required to correct for this. At Greenwich the polar axes of the photographic equatorials have been adjusted so that when the instrument is pointed to, or near, the Pole, and the clock is rated to sidereal time, no elongation of the images occurs. This implies that the polar axis of the telescope does not point to the true, but to the apparent Pole (as affected by refraction). That this is the case can be easily seen by making the supposition that there is a star at the Pole. This will be seen at the apparent Pole, and to obtain a round image of it the polar axis of the equatorial must be pointed to it.

When an equatorial is adjusted in this manner the alteration required in the rate of the clock in order to keep the telescope accurately pointed is very different from that required when refraction only is considered, and does not become infinite at the Pole, which would not be the case if the axis were adjusted to the true Pole. But even if a telescope is not adjusted in this way, as the polar axis is rarely pointed accurately to the true Pole, it may be of interest to consider the effect of this error.



Leaving out refraction and considering only the elevation of the Pole, if P is the true, P_1 the instrumental Pole, z the zenith, and s a star,

Then

$P P_1$ is the error of elevation $= e$.

$z P s$ is the hour angle of the star $= h$.

$$P s = \frac{\pi}{2} - \delta.$$

$z P_1 s$ is the hour angle as shown by the telescope.

Therefore

$$\Delta h = e \sin h \,.\, \tan \delta.$$

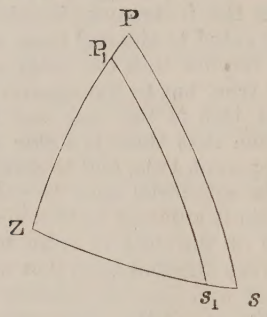
And

$$\frac{d \Delta h}{d h} = e \cos h \,.\, \tan \delta,$$

which, e being known, may be easily applied as a correction to Professor Rambaut's table.

But I wish to consider at greater length the result when, as

at Greenwich, P_1 is also the apparent Pole, combining with it the variation due to refraction.



As before z, P, and s are the zenith, pole, and a star.
P_1 the apparent and instrumental Pole.
s_1 the star as affected by refraction.
Then

$$z\,P = \text{colatitude} = c,$$

$$z\,s = \text{zenith distance} = z,$$

$$P\,s = \frac{\pi}{2} - \delta,$$

and

$$P\,s\,z = \text{angle Q}.$$

Then

$$\Delta h = -\Delta c \sin h \,.\, \tan \delta + \Delta z \frac{\sin h \,.\, \sin c}{\sin z \,.\, \cos \delta}.$$

Putting $\Delta c = -k \tan c$,
and $\Delta z = -k \tan z$, where k is the constant of refraction ; this becomes

$$\Delta h = -k \sin h \,.\, \tan c \tan z \,.\, \cos Q,$$

and the change of rate is given by

$$\frac{d\Delta h}{dh} = -k\,(\tan c \,.\, \cos h \tan z \,.\, \cos Q + \sin^2 c \,.\, \sin^2 h \sec^2 z).$$

The computation of tables from this formula is simplified by the introduction of an auxiliary angle θ defined by

$$\tan \theta = \tan c \,.\, \cos h,$$

for

$$\tan z \,.\, \cos Q = \frac{1 - \tan c \tan \delta \,.\, \cos h}{\tan \delta + \tan c \,.\, \cos h}$$

$$= \cot (\delta + \theta),$$

and

$$\cos z = \frac{\cos c \sin (\delta + \theta)}{\cos \theta},$$

and the formula then becomes

$$\frac{d\Delta h}{dh} = -k \left\{ \tan \theta \cot (\delta + \theta) - \frac{\tan^2 c \,.\, \sin^2 h \cos^2 \theta}{\sin^2 (\delta + \theta)} \right\}.$$

When special cases are considered some interesting modifications occur in the formula.

On the meridian it simplifies to

$$\frac{d\Delta h}{dh} = -k \tan c \tan z,$$

and at 6^{hrs} from the meridian

$$\frac{d\Delta h}{dh} = -k \tan^2 c \,.\, \operatorname{cosec}^2 \delta.$$

Near the Pole the rate is

$$+k \tan^2 c \cos 2h.$$

It should be noted that this is finite, and that the elongation of the image of any star will be infinitesimal.

It will be observed that the effect of this adjustment disappears at the equator, and also at six hours from the meridian, leaving the effect due to refraction only, and is greatest near the Pole on the meridian, where the effect of refraction is eliminated.

Table I. exhibits the results obtained, in daily rates, + signifying a gaining and — a losing rate.

TABLE I.

Hour Angle.

Decl. °	0h s	1h s	2h s	3h s	4h s	5h s	6h s	7h s	8h s	9h s	10h s	11 s	12h s
−20	−57·3	−65·6	−104·6										
15	−44·1	−49·0	− 69·7										
10	−35·3	−38·5	− 51·3	−91·2									
− 5	−29·0	−31·2	− 39·9	−63·9									
0	−24·1	−25·8	− 32·1	−48·1	−96·3								
+ 5	−20·2	−21·6	− 26·5	−38·0	−68·1								
10	−16·9	−18·1	− 22·1	−30·9	−51·3	−112·7							
15	−14·2	−15·2	− 18·6	−25·7	−40·5	− 77·9							
20	−11·7	−12·7	− 15·7	−21·7	−33·1	− 57·7	−130·5						
25	− 9·6	−10·4	− 13·2	−18·5	−27·7	− 45·0	− 85·5						
30	− 7·6	− 8·4	− 11·1	−15·9	−23·6	− 36·5	− 61·1	−123·0					
35	− 5·7	− 6·5	− 9·1	−13·6	−20·4	− 30·5	− 46·4	− 75·5					
40	− 3·9	− 4·8	− 7·4	−11·7	−17·9	− 26·2	− 37·0	− 51·4	−71·5				
45	− 2·2	− 3·1	− 5·7	−10·1	−15·8	− 22·9	− 30·5	− 37·7	−41·0	−31·8			
50	− 0·5	− 1·4	− 4·2	− 8·5	−14·1	− 20·3	− 26·0	− 29·2	−26·2	−10·7			
55	+ 1·2	+ 0·2	− 2·7	− 7·2	−12·7	− 18·4	− 22·8	− 23·8	−18·2	− 2·7	+23·3	+51·8	+64·8
60	+ 2·9	+ 1·8	− 1·3	− 6·0	−11·5	− 16·8	− 20·4	− 20·1	−13·6	+ 0·6	+20·9	+40·4	+48·7
65	+ 4·6	+ 3·5	+ 0·1	− 4·8	−10·5	− 15·6	− 19·5	− 17·6	−10·8	+ 1·8	+18·2	+32·6	+38·5
70	+ 6·4	+ 5·2	+ 1·5	− 3·7	− 9·6	− 14·7	− 17·3	− 15·8	− 9·2	+ 2·1	+15·6	+26·9	+31·3
75	+ 8·3	+ 6·9	+ 3·0	− 2·7	− 8·9	− 14·0	− 16·4	− 14·7	− 8·2	+ 1·9	+13·4	+22·4	+25·9
80	+10·4	+ 8·8	+ 4·5	− 1·8	− 8·3	− 13·5	− 15·7	− 13·9	− 7·7	+ 1·4	+11·3	+18·9	+21·7
85	+12·7	+10·9	+ 6·0	− 0·8	− 7·9	− 13·3	− 15·4	− 13·4	− 7·6	+ 0·8	+ 9·4	+15·8	+18·2
+90	+15·3	+13·2	+ 7·6	− 0·0	− 7·6	− 13·2	− 15·3	− 13·2	− 7·6	0·0	+ 7·6	+13·2	+15·3

The following table is a comparison of the necessary changes in the clock rate near the meridian when the polar axis is adjusted to the true Pole with those when it is adjusted to the apparent Pole :—

TABLE II.

Decl.	Rate on the meridian polar axis adjusted to the True Pole.	Apparent Pole.	Decl.	Rate on the meridian polar axis adjusted to the True Pole.	Apparent Pole.
°	s	s	°	s	s
−20	−52·0	−57·3	+55	− 25·6	+ 1·2
15	40·5	44·1	60	29·4	2·9
10	32·7	35·3	65	35·6	4·6
− 5	27·8	29·0	70	44·5	6·4
0	24·3	24·1	75	63·3	8·3
+ 5	22·0	20·2	80	− 94·0	10·4
10	20·3	16·9	85	...	12·7
15	19·2	14·2	90	...	15·3
20	18·6	11·7	85 S.P.	...	18·2
25	18·3	9·6	80 S.P.	+121·9	21·7
30	18·4	7·6	75 S.P.	93·4	25·9
35	18·9	5·7	70 S.P.	76·9	31·3
40	19·6	3·9	65 S.P.	70·5	38·5
45	21·1	2·2	60 S.P.	72·0	48·7
+50	−22·8	− 0·5	55 S.P.	+79·7	+64·8

As regards the change in the apparent declination of a star due to this adjustment

$$\Delta\delta = -\Delta c \cos h,$$

and

$$\frac{d\Delta\delta}{dh} = +\Delta c \sin h,$$

h being the westerly hour angle.

This change will be seen to vanish on the meridian, but, on either side of it, will go in an opposite direction to that due to refraction.

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

The Great Equatorial Current of Jupiter.

By A. Stanley Williams.

I. *On the Rate of Rotation in* 1897.

Observations were made here last spring with the object of determining the present rate of rotation of the great equatorial current of *Jupiter*. Valuable observations were also received from the undermentioned observers, and have been of great assistance in this research—namely, Messrs. E. M. Antoniadi, Juvisy; L. Brenner, Lussinpiccolo; H. F. Griffiths, Streatham; H. MacEwen, Glasgow; W. H. Maw, South Kensington; T. E. R. Phillips, Yeovil. So that, although the weather proved exceptionally unfavourable, eight spots situated on the north side of the south equatorial belt were observed sufficiently well to enable good determinations of the rotation period to be derived. The observations of these spots are given further on.

In all work of this kind it is of the utmost importance that there should be no possibility of doubt concerning the identity of the markings observed. It is very desirable, therefore, that observers, when stating the results of their investigations, should publish also the observations upon which these results are based; and this is even more important when such results differ materially from those of earlier investigators. In the present instance I have been careful not to include any doubtful cases, and the observations are so numerous, so distributed, and so accordant, that it seems impossible that there can be any doubt as to identity. Most of the columns in the following tables explain themselves. The third column gives the weight attributed to the observation at the time on a scale ranging from 1 (bad) to 5 (good).* The rotation periods have been computed from certain selected observations, and these weights are useful in selecting the best observations, but they have not been made use of in any other way in the calculations. The residuals in the fifth column will show how far the observations are satisfied by the adopted period of rotation in the case of each spot. The longitudes in column 4 are according to "System 1" of the late Mr. Marth's Ephemeris. The last column contains the initials of the observer.†

* For the meaning of "est." = estimated transit in connection with an observation by Mr. MacEwen, see *Journal B.A.A.* vol. vii. p. 271; and in connection with an observation by the writer, see *Monthly Notices*, vol. liv. p. 298.

† Most of the transits of equatorial spots by Mr. Gledhill, published in the Supplementary Number of the *Monthly Notices*, refer to spots on the N. equatorial belt. An observation of the dark spot *b* on May 9 has, however, been added in its proper place. A small *bright* spot on the N. edge of his belt 3 is stated to have been on the central meridian, at $8^h\ 27^m$, on April 28. This would give a position close to the *dark* spot *c*, so that belt 3 is probably a misprint for 5.

White Spot a.

Date 1897	G.M.T. of Transit. h m	Wt.	Longitude. °	O−C. m	Observer.
Feb. 18	9 40·9	...	39·0	+ 3·7	L. B.
25	8 54·8	...	37·1	− 1·5	,,
Mar. 6	9 27	3	38·8	− 1·4	A. S. W.
8	10 40·3	3	39·6	− 0·8	,,
10	11 57·7	2	42·9	+ 4·0	,,
19	12 27·1	2	42·4	+ 0·5	,,
Apr. 3	6 44·6	...	42·6	− 3·8	L. B.
9	10 40	est.	(53·5)	(+12·1)	H. M.
25	10 24	2	49·3	+ 0·3	A. S. W.
30	8 38·6	...	54·1	+ 6·7	L. B.
May 9	9 4·4	...	50·0	− 2·9	,,
9	9 4·5	2	50·0	− 2·8	A. S. W.

Dark Spot b.

Feb. 11	10 44	4	(51·1)	(+ 6·5)	H. M.
27	10 35·9	...	(54·7)	(+ 6·8)	T. E. R. P.
Mar. 6	9 53	3	(54·7)	(+ 4·2)	A. S. W.
8	11 0·8	4	52·1	− 0·8	,,
10	12 14·7	3	53·3	+ 0·5	,,
Apr. 25	10 47	est.	63·3	+ 0·7	,,
30	8 55	3	64·1	+ 0·3	,,
May 9	9 30	2	65·6	− 0·5	,,
9	9 19	...	(58·9)	(−11·5)	J. G.

Dark Spot c.

Feb. 23	9 13	est.	92·1	+ 1·5	A. S. W.
Mar. 1	12 45·9	...	90·0	− 2·1	T. E. R. P.
6	10 54	3	91·9	+ 0·7	A. S. W.
8	12 4·3	3	90·8	− 1·2	,,
Apr. 7	10 34·7	est.	94·4	+ 3·6	,,
14	9 47	1	90·5	− 3·2	,,
30	9 42	2	92·8	− 0·1	,,
May 14	8 23	3	93·6	+ 0·7	,,

Date	G.M.T. of Transit.	Wt.	Longitude.	O—C.	Observer.
	White Spot d.				
1897	h m		°	m	
Jan. 17	11 52	1	101·8	+ 3·1	H. M.
Feb. 23	9 29	3	101·9	− 1·6	A. S. W.
Mar. 6	11 14	2	104·1	+ 0·6	,,
8	12 25·3	1	103·6	− 0·5	,,
Apr. 7	10 55·7	2	107·2	+ 1·6	,,
14	10 10	2	104·5	− 3·8	,,
30	9 57·4 (?)	...	(102·2)	(− 9·7)	L. B.
May 14	8 49	1	109·4	+ 0·4	A. S. W.
	Dark Spot e.				
Jan. 17	12 0	2	106·7	− 0·1	H. M.
Apr. 28	9 21·2±	...	124·4	+ 3·2	A. S. W.
May 5	8 38·7	est.	123·2	− 0·6	,,
14	9 15	2	125·3	+ 0·7	,,
	White Spot f.				
Apr. 10	10 48·5	2	216·5	− 3·4	A. S. W.
24	9 36	2	222·2	+ 3·9	,,
May 3	10 4·8	est.	220·1	− 0·9	,,
June 25	8 3·3	...	225·7	+ 0·6	L. B.
	Dark Spot g.				
Feb. 3	(13 8)	2	(314·6)	(− 7·3)	H. M.
Mar. 19	10 15·1	2	321·9	− 1·2	A. S. W.
Apr. 27	9 18·2	2	324·9	− 1·5	,,
May 4	8 43·3	est.	328·2	+ 3·0	,,
6	9 55·8	est.	328·0	+ 2·4	,,
13	9 12·5	1	326·0	− 1·8	,,
20	8 34·5	2	327·2	− 0·8	,,
	Dark Spot h.				
Feb. 3	14 0	est.	346·3	− 1·1	H. M.
Apr. 25	8 49	3	351·5	− 3·1	A. S. W.
27	10 11·2	1	357·2	+ 6·0	,,
May 4	9 23·3	2	352·6	− 2·4	,,
13	9 57·5	1	353·5	− 2·1	,,
15	11 15·5	1	356·5	+ 2·6	,,

Notes.

Spot b. The rot. per. depends upon the observations from Mar. 8 to May 9. On Mar. 6 the spot appeared as a close double spot, a smaller companion lying just following. The time given is that of this double spot considered as

one mass. The observations of Feb. 11 and 27 also evidently relate to the same phase. The later ones refer to the preceding component.

Spot g. This spot was on the north side of the S. Equat. Belt. The observation of Feb. 3 refers to a dark streak on the south edge of the same belt. It is doubtful, therefore, how far this observation relates to Spot *g*, if it does so at all.

Spot h. On April 27 the spot was double and observed as one mass. The last observation was made with a $2\frac{3}{4}$-inch refractor. The transits observed by Mr. Phillips being uniformly earlier than those by the writer, the times given here are the observed times + $5^m{\cdot}9$, the average amount of the difference (from four comparisons).

The following are the adopted periods of rotation, together with the number of rotations elapsed between the first and last observations on which each period is based.

Spot.	Per. of Rotation.	No. of Rotations.	Spot.	Per. of Rotation.	No. of Rotations.
	h m s			h m s	
a	9 50 37·6	156	*e*	9 50 36·3	285
b	38·7	151	*f*	33·6	185
c	31·0	195	*g*	33·3	151
d	33·2	285	*h*	33·2	241

Mean = $9^h\ 50^m\ 34^s{\cdot}6$ (8 spots).

The mean period of rotation of the equatorial current in 1897 was therefore $9^h\ 50^m\ 34^s{\cdot}6$. This relates to the southernmost portion of the current, to which nearly all previous determinations also refer. The above eight spots were all situated on the north side of the south equatorial belt.*

II. *On the Change in the Rate of Rotation of the Equatorial Current.*

One of the most remarkable facts known in connection with the physical condition of the planet *Jupiter* is the continual decrease in the velocity of the equatorial current since 1879. A list of the different determinations of the period of rotation of this current will be found in the *Monthly Notices*, vol. lvi. p. 147. In order to reduce these into a more manageable form, each result has been given an arbitrary weight. Generally, each determination of the rotation period of a spot has been given weight 1, but a less weight has been assigned wherever the interval of time covered by the observations is short, or there are any other circumstances which might affect the accuracy of the result. The average values for each opposition have then been

* Two prominent dark spots on the south edge of the north equatorial belt give the following results:

Dark spot *i* R = $9^h\ 50^m\ 32^s{\cdot}3$ (217 rotations).

„ „ *k* R = $9^h\ 50^m\ 39^s{\cdot}7$ (156 „).

found from these weighted results,* and are given in the following table:—

Opposition.	Mean Per. of Rot. h s m	Weight.	C−O. s
1879	9 49 59	1	0·0
1880	9 50 5·0	7	−1·8
1881	10 2	2	−3·2
1882	9·7	2	+1·0
1884	12·4	2	+1·7
1885	14·3	1	+2·9
1886	22·9	1	−2·8
1887	22·4	21	+0·3
1888	31·4	3	−6·3
1891	26·4	1	+4·2
1897	34·6	8	−0·1

The above table shows clearly the remarkable and continual increase in the period of rotation since 1879, a period of eighteen years. The total increase in the period of rotation since 1879 is $35^{s}\cdot6$, and this is equivalent to a decrease of 26 miles (42 kilometres) per hour in the actual velocity of the current. The decrease in velocity, however, clearly takes place at a slower rate now than formerly, as is evident from the preceding table, which shows also that there has been a progressive decrease in the rate of change. The observed changes in the length of the period of the equatorial current are represented well enough by the formula $R = 9^{h}\ 49^{m}\ 59^{s} + t \times (4^{s}\cdot3 - 0^{s}\cdot13t)$, where R is the period of rotation and t the interval of time expressed in oppositions of *Jupiter* elapsed since 1879. The residuals C—O have been added in the last column of the foregoing table in order to show how far the observed values are represented by this formula. The increase in the length of the rotation period has apparently now nearly come to an end, and after next year should be succeeded by a decrease, which would mean of course an increase in the actual velocity of the current, though the change at first would be small. It is very desirable, therefore, that the rate of rotation should be re-determined in the next and succeeding apparitions of *Jupiter*. And the importance of basing such determinations on the observations of a number of spots cannot be too strongly insisted upon.

1897 October 18.

* The effect of this mode of combination is to give a relatively high weight to a result based upon a large number of spots.

On the Nature of the Orbit of γ Lupi. By T. J. J. See, A.M., Ph.D. (Berlin).

The brilliant southern binary γ *Lupi* was discovered by Sir John Herschel, at the Cape of Good Hope, 1834 June 9. The measures secured by him during the next four years define the place of the companion at that epoch with considerable precision; and, as might have been predicted from the appearance of this striking system, time has shown that it is in orbital motion. After Herschel's return to England a long period elapsed before it was again resolved by any telescope in the southern hemisphere, though it was frequently examined with instruments at least equal to that employed in the earliest work at the Cape.

Mr. Russell, of Sydney, deserves our special thanks for the records secured by him from 1874 to the present time with his 11½-inch telescope, which under good conditions ought to separate a nearly equal pair like γ *Lupi* at a distance of 0″·4. For, although these records are of a negative character, they possess the highest interest. The fact that Mr. Russell and his assistants examined this object on many occasions prior to 1880, without being able to divide it, long ago made known that it had narrowed up after the time of Herschel. As the Sydney observers are still unable to divide it, the observations recently secured by Mr. Cogshall and the writer with the Lowell 24-inch refractor at Mexico are the first actual measures of the system for sixty years. These data define the present position of the companion with a high degree of precision, and throw an interesting light upon the character of the orbit; and hence I submit herewith the conclusions at which we have arrived. We swept over the star (unaware that it was γ *Lupi*) on the morning of 1897 January 17, and I saw at once that it was double, and indeed divided clearly, though by no means a very easy object even with the great telescope. It was subsequently re-examined on several nights, and no difficulty was experienced in securing good measures; yet when the seeing was deteriorated it became difficult to measure, and thus during our later work this well known object served as a most trustworthy and convenient index to the state of the atmosphere. Here at Flagstaff, notwithstanding the low altitude of only 14°, the fine seeing afforded by our location has enabled me to divide it on several occasions during the past summer. The following are all the observations to the present time:—

Complete Observations of γ Lupi.

t	θ	ρ	n	Observers.	Remarks.
1834·504	98°·5	0·72	3	Herschel	Refractor.
1835·335	94·8	0·85	6–2	,,	,,
1836·282	93·0	1·00	2–1	,,	,,
1836·523	95·5	0·67	1	,,	Reflector
1837·265	94·8	0 67	4–2	,,	Refractor
1871·465	Well defined but not divided.		...	Russell	7½-inch refractor.
1877·502	270° ± smaller end goes first.		...	,,	11½-inch; powers 480, 800, 1,200.
1880·578	270 ± elongated.		...	,,	
1881·548	Round, with powers to 800.		...	,,	
1886·570	Uncertain elong. in 90°.		...	,,	Definition not good.
1886·570	Round, with all powers on 7½-inch telescope.		...	Pollock	
1887·531	Single. with 800 on 11½-inch.		...	,,	Never saw better definition; *γ Lupi* is not like *ζ Sagittarii* measured on the same night. Dist. 0″·6.
1895·56	Single, good definition.		3	Sellors	
1897·065	92°·4	0″·34	2	See	Nicely separated.
1897·086	90·4	0·47	1	Cogshall	Divided.

Our measures indicate that the present distance is slightly less than 0″·4, and hence we may easily understand Mr. Russell's inability to divide it. He writes in a letter of August 30: "We have regularly looked at it, and always without dividing it. The last time it was in a favourable position, Mr. Sellors examined it several times, and could see no sign of division." Herschel's measures show that it was not very difficult in his time. Taking all the evidence into consideration, we may fix the place as substantially this:

1835·0 94° 0″·8

The distance at that epoch could hardly be less than 0″·8, for Herschel remarks: "Clearly divided with power of 480, and black division well seen; well separated with 800." And in speaking of *π Lupi* he says: "Excessively difficult It is closer than *γ Lupi*, for the discs are smaller, and yet are not so much divided." "I do not think better measures of this star will be got

with this instrument." Herschel made the distance of π *Lupi* 0″·67 (on other occasions about 0″·80); and as this object is known by more recent measures to be steadily widening out, we may accept his distance of π *Lupi* as quite trustworthy. For taking the present distance (1″·30) of π *Lupi*, and going back in time, we find that in 1835 it must have been separated by at least 0″·75. Assuming, therefore, that γ *Lupi* was separated by 0″·8 in 1835, we may summarise the case as follows :—

1. The present position in 92°, 0″·34 shows that the plane of the orbit passes nearly through the Sun, and that the companion thus oscillates in a right line like that of 42 *Comæ Berenicis* (*Monthly Notices*, 1896 November).

2. Assuming that the distance was 0″ 8 in 1835, as indicated by the work of Herschel, the present distance, 0″·34, shows that in 1877 it ought to have been easily separated with an 11½-inch telescope had the companion merely narrowed up at about a constant rate without yet occulting the large star; for on this hypothesis the distance would then have been 0″·50. Mr. Russell made it on the opposite side, in 270°±, and presumably at a distance of about 0″·35. In describing the image he expressly notes that the "smaller end goes first"

3. In view of Mr. Russell's inability to divide the object in 1877, we may infer that the distance had certainly become less than 0″·4, and that the companion had widened out to about this distance on the other side. It is thus clear that the companion has passed periastron, and is now again approaching the position where Herschel saw it in 1835.

4. We thus have satisfactory evidence that γ *Lupi* has already made a large part of a revolution, and that the situation of the orbit is similar to that of 42 *Comæ Berenicis*, which heretofore has been unique among all known stellar systems.

5. The period cannot yet be fixed with any precision, for we are unable to ascertain the distance to which the companion recedes in angle 93°. If the distance in the time of Herschel was about a maximum (which is not improbable) the period could be confined within a century.

It thus appears that the system of γ *Lupi* is in every way one of surpassing interest, and will deserve the constant attention of southern observers. If careful measures can be secured for the next twenty years, an approximate determination of the orbit will then be possible. The system has a very small proper motion, according to Auwers:

$$\text{in } \alpha = -0^{s}\cdot0054$$
$$\text{in } \delta = -0''\cdot037$$

Accordingly, there is a probability that this extraordinary binary is very remote and of large dimensions. If this conjecture be true, the brilliancy of the stars composing it shows that they are enormously luminous and probably of great mass.

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The place for 1900·0 is

$$\alpha = 15^{h}\ 28^{m}\ 28^{s}\cdot4$$
$$\delta = 40^{\circ}\ 49'\ 50''\cdot2$$

While the present results indicate the general character of the motion, it is obvious that the work of many years will be required to define the orbit with great accuracy; yet I have thought proper at this time to direct attention to the first fruit of what must be considered to be one of the most fortunate of Herschel's discoveries made more than sixty years ago.

Lowell Observatory, Flagstaff, Arizona:
1897 *October* 1.

List No. 4 for 1900·0 *of Nebulæ discovered at the Lowe Observatory, California.* By Lewis Swift.

No.	Date. 1897.	R.A. h m s	Dec. ° ′ ″	Descriptions.
1	Sept. 23	0 11 0	−39 52 20	eeeF, vL, eE, close f 55, f of 2. Note.
2	Oct. 3	0 54 30	−34 51 32	pB, vS, R, 2 st nf, and 2 np.
3	Sept. 29	1 5 0	−46 31 38	vF, S, R, no B ✶ near, vF one f.
4	29	1 53 4	−33 31 27	pB, vS, R, BM 10^{m} ✶ v close sp.
5	29	2 5 0	−33 25 0	vF, vS, eE, nearly 0°, F ✶ p.
6	29	2 59 28	−39 52 38	eF, pS, R, FD ✶ sf point to it.
7	26	3 31 0	−34 46 55	pB, S, eeeE, a straight hair-like line 90°. Note.
8	29	4 8 45	−33 7 51	eF, vS, R, BM, 10^{m} ✶ close s.
9	29	4 16 30	−31 41 42	eeF, pL, R.
10	Aug. 10	19 53 30	−38 47 38	vF, S, R, 8^{m} ✶ f, 90°, p of 2, same parallel.
11	10	19 54 0	−38 47 38	vF, S, R, 8^{m} ✶ f, f of 2.
12	July 8	20 0 0	−48 35 50	B, cE, vS, stellar, f of 2.
13	Sept. 23	20 10 59	−41 53 24	vF, cS, R, no B ✶ near.
14	16	20 24 25	−36 39 15	vF, cS, R, several pB st sf.
15	17	20 40 25	−38 50 35	eeF, pS, R.
16	15	21 1 31	−30 26 30	eeF, pS, R, F ✶ near f, 90°.
17	17	21 41 0	−35 21 58	vF, vS, R.
18	17	21 42 0	−35 27 0	vF, pL, R. Not 7130 or 7135; sp of 2.
19	17	21 43 30	−35 22 10	eeF, pL, R, 3 B st p = Δ nf of 2.
20	27	21 49 46	−49 31 52	eeF, pS, R, in line with 2·9^{m} st sf, 7^{m} ✶ in field sf.
21	23	22 51 30	−43 59 27	pB, S, R, mbM.
22	Oct. 3	23 27 45	−45 35 40	vF, S, R, bet 2 st, 8^{m} ✶ sf and 7^{m} ✶ sp.
23	Sept. 23	23 39 25	−43 29 15	eF, eS, R, stellar.
24	25	23 42 40	−37 36 53	eeF, CS, R, in vacancy.
25	25	23 52 25	−37 34 52	pB, CS, eE, 1 star near sf.

Notes.

This list, the fourth issued from this observatory, bringing the total to 130, contains, as will be seen, only southern nebulæ. They are, with a few exceptions, very faint, though some are bright enough to come under Herschel's Class I., and the fact of their not having been previously found shows that the southern sky has not been so thoroughly searched over for nebulæ as the northern, and that portion of the southern within the reach of Sir William Herschel and Lord Rosse.

Note to No. 1 = G.C., 27 = N.G.C. 55, is with its associated companion a remarkable nebula. I am at a loss what to think of it, whether it is all one nebula, the preceding half vv bright, v large, exceedingly elongated, the following half ee faint, equally large, and still more elongated, or if there are not two nebulæ, one partly overlapping the other. If single, it is curved; if double, the compouents are inclined to each other. I am inclined to think there are two distinct nebulæ, one reason being that the brighter one ends sharply, which would hardly be the case if the brighter merged into the fainter. The brighter was discovered by Dunlop, but I doubt if he could have seen the fainter. The fact that Sir John Herschel does not mark it with a sign meaning a very remarkable or even a remarkable object—as he often has done —lends plausibility to the supposition that the fainter portion was not seen by him. As, however, it has been illustrated, a reference to the illustration would settle the matter at once.

No. 7. This in one respect is the most remarkable nebula I have ever seen. I doubt if the entire heavens afford a similar example. If the reader will cut off a short piece of fine bright brass wire and hold it up sidewise to the sky he will form by looking at it a very correct idea how it appeared to me. The line was certainly nebulous. It must be a thin nebulous disc seen exactly edgewise.

G. C. 383 does not exist, and must be struck out. Sir John Herschel makes 380 and 383 of equal brightness, and the places given would place both well within my field of 31′ in diameter, power 132. I made a long and thorough search for 383, and should have found it if there, had it been three times fainter than 380, which is an easy object.

Occultation of the Pleiades, 1897 *July* 23.

By W. E. Plummer, M.A.

The following observations were made at Bidston Observatory, under decidedly unfavourable meteorological conditions. The sky was repeatedly covered with cloud, and a haze was at all times present which rendered some of the stars very faint when near the limb of the Moon, and also interfered with definition. No apparent projection of the stars on the Moon's disc was noticeable at either disappearance or re-appearance. The nomenclature is that of Bessel.

Star.	Phenomenon.	Observed Local Time. h m s	Star.	Phenomenon.	Observed Local Time. h m s
Electra	Disappearance	12 9 25·3	Alcyone	Disappearance	13 13 19·9
8	,,	12 44 14·5	Merope	Re-appearance	13 27 29·3
Merope	,,	12 44 53·0	9	,,	13 39 33·3
4*	,,	12 53 45·8	29	Disappearance	13 46 15·1
13	,,	12 58 49·0	Pleione	,,	14 4 52·8
15	,,	13 2 0·5	Alcyone	Re-appearance	14 7 29·5
18	,,	13 8 38·1	32	Disappearance	14 9 30·7
p	,,	13 9 23·5			

Liverpool Observatory:
1897 *November* 11.

* In the case of this star some doubt was entertained whether the star was really occulted or simply obscured by cloud at the time of closest approach. The path of the Moon seemed to indicate that it would be hidden, but suspicion was raised when seen later.

Equatorial Comparisons of Uranus with 41 Libræ, and a Probable Occultation of the Star by the Planet. By John Tebbutt.

On 1897 September 5 I commenced a series of comparisons of *Uranus* and 41 *Libræ* by means of the 8-inch equatorial and filar micrometer. On completing the first three nights' observations it appeared to me that the planet would, on the evening of September 8, either occult the star or approach extremely close to it. As absence from home would prevent my observation of this interesting appulse, I requested two prominent Members of the local branch of the British Astronomical Association to watch for the phenomenon. I have since heard from Mr. C. J. Merfield that he saw the planet within 5″ of the star at $7^h\ 20^m$, and concluded that it had been much closer at sunset. He afterwards found from the theoretical places in the *Nautical Almanac* that the star must have suffered occultation shortly before sunset, and the observed coordinates communicated in this paper will confirm this conclusion. The accompanying observations have been made under fairly good conditions, and many of them during twilight. The centre of the planet's disc was the point observed throughout.

The star's mean place for 1897·0 has been derived from the following catalogues: –Greenwich, 1840, 1850, 1880; Cape, 1850, 1885; Argelander-Oeltzen, 1850; Radcliffe, 1860, 1890; Washington, 1860, 3rd ed.; Brussels, 1865; Cordoba, 1875; and Melbourne, 1880. The reductions for mean place have been made by means of the annual precessions and secular variations of the Greenwich Catalogue, 1880, checked by those of the Radcliffe Catalogue, 1890, and the proper motion has been taken from the same two authorities. The resulting mean place, assigning equal weights to the authorities, is R.A.$=15^h\ 32^m\ 58^s{\cdot}70$, N.P.D.$=108°\ 57'\ 45''{\cdot}1$ The observations have been compared with the transit ephemeris on p. 279 of the *Nautical Almanac*, and the means of the resulting corrections, namely $-0^s{\cdot}35$, $-0''{\cdot}8$, agree closely with $-0^s{\cdot}32$, $-1''{\cdot}2$, the results derived by me from comparisons with *a Libræ* on 1894 October 5. See *R.A.S. Monthly Notices*, vol. lv. p. 83. In concluding this paper I would suggest the desirability of improving the Table of Phenomena in the *Nautical Almanac* by the more free insertion of conjunctions of planets with well-known stars, for results derived from micrometric measures at such opportunities are, I think, quite equal to those from ordinary meridian observations. I may add that *Neptune* will pass within micrometric distance of 114 *Tauri* at his opposition in December next.

Results of Micrometer Comparisons of Uranus and 41 Libræ.

1897.	Windsor Mean Time.	Comps.	Planet's Centre −Star. R.A.	Planet's Centre −Star. N.P.D.	Star Reductions. R.A.	Star Reductions. N.P.D.	Parallax Corrections. R.A.	Parallax Corrections. N.P.D.	Geocentric Apparent Place of Planet's Centre. R.A.	Geocentric Apparent Place of Planet's Centre. N.P.D.	Corrections to *Nautical Almanac*. R.A.	Corrections to *Nautical Almanac*. N.P.D.
	h m		s	′ ″	s	″	s	″	h m s	° ′ ″	s	″
Sept. 5	7 9 31	30	−21·10	−1 18·6	+2·84	+14·6	+0·02	+0·2	15 32 40·46	108 56 41·3	−0·30	−1·5
6	6 48 38	30	−14·18	−0 52·5	+2·83	+14·6	+0·02	+0·1	15 32 47·37	108 57 7·3	−0·29	−0·8
7	7 47 6	30	−6·68	−0 25·5	+2·81	+14·5	+0·02	+0·2	15 32 54·85	108 57 34·3	−0·31	−1·2
9	7 18 29	30	+8·14	+0 29·0	+2·79	+14·5	+0·02	+0·2	15 33 9·65	108 58 28·8	−0·34	−0·5
10	6 32 9	30	+15·66	+0 56·2	+2·77	+14·4	+0·02	+0·1	15 33 17·15	108 58 55·8	−0·36	−0·8
11	7 7 10	30	+23·83	+1 26·0	+2·76	+14·4	+0·02	+0·2	15 33 25·31	108 59 25·7	−0·35	−0·3
12	6 49 27	13	+31·75	+1 55·1	+2·74	+14·3	+0·02	+0·2	15 33 33·21	108 59 54·7	−0·49	−0·3
13	7 36 57	20	+40·47	+2 25·8	+2·73	+14·3	+0·02	+0·2	15 33 41·92	109 0 25·4	−0·37	−0·6

Windsor, N.S. Wales:
1897 *September* 25.

Observations of Comet b 1897 (*Perrine*) *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power, 55.

Greenwich Mean Solar Time.				Observer.	Comet − ✶ R.A.	Corr. for Refraction.	Log. Factor of Parallax.	Comet − ✶ N.P.D.	Corr. for Refraction.	Log. Factor of Parallax.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1897. d	h	m	s		m s	s		′ ″	″			h m s	° ′ ″	
Oct. 21	10	42	19	C. D.	−4 11·35	+0·04	9·8596*n*	−6 18·7	+0·2	0·4014	4	2 57 32·84	16 5 7·3	*a*
21	10	44	46	,,	−3 25·57	−0·04	9·8522*n*	+5 19·6	−0·1	0·4063	3	2 57 30·88	16 4 55·5	*b*
24	8	0	2	W.	+0 57·49	+0·01	0·1755*n*	−0 36·0	0·0	0·1033	6	2 11 36·45	12 12 17·9	*c*
24	8	0	2	,,	+0 48·00	+0·09	0·1755*n*	−4 29·9	+0·1	0·1033	6	2 11 34·17	12 12 18·6	*d*
25	7	6	30	C. D.	+0 31·90	+0·08	0·2381*n*	−3 36·6	+0·1	9·9157	9	1 49 27·96	11 5 24·6	*e*
26	8	59	23	A. C.	+1 18·96	+0·03	0·0191*n*	−1 49·6	+0·1	0·5478	3	1 19 32·20	10 0 39·2	*f*
30	6	40	38	C. D.	+0 6·19	−0·06	9·9871*n*	+3 37·1	−0·2	0·6064	6	22 48 24·51	8 19 10·7	*g*

Notes.

The observations are corrected for refraction, but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the comet.

Oct. 21.—The Comet was bright.

Oct. 24.—The Comet was fairly bright, with faint nucleus and a short tail.

Oct. 26.—The night was hazy and the Comet faint and ill-defined.

Oct. 30.—The Comet appeared much fainter.

The initials A. C., C. D., and W. are those of Mr. Crommelin, Mr. Davidson, and Mr. Witchell respectively.

Comparison Stars.

	Star's Name	Assumed R.A. 1897·0. h m s	Assumed N.P.D. 1897·0. ° ′ ″	Authority.
a	Groombridge 604	3 1 33·74	16 11 42·0	Greenwich Ten-Year Catalogue, 1890 (Manuscript).
b	Bradley 417	3 0 46·01	15 59 52·3	,, ,, ,, ,,
c	Groombridge 469	2 10 27·32	12 13 16·8	,, ,, ,, ,,
d	Oeltz. Arg. (N) 2523	2 10 34·50	12 17 11·3	Oeltzen-Argelander (North).
e	BD + 78° No. 63	1 48 44·25	11 9 26·6	Bonn Observations, vol. vi.
f	Anonymous	1 18 1·85	10 2 57·4	Greenwich Observations, 1897.
g	Carrington 3503	22 48 15·50	8 16 10·3	Carrington's Red Hill Catalogue.

Royal Observatory, Greenwich:
1897 *November* 12.

Approximate Ephemeris of the Leonids, from 1897 *December* 24 *to* 1898 *April* 8.

(*Communicated by G. Johnstone Stoney, D.Sc., F.R.S.*)

The following ephemeris of the part of the swarm of the *Leonids* which passed close to the Earth in 1866 is a continuation of the ephemeris in the *Monthly Notices* for 1896 December, and is intended to prepare for another attempt to photograph the meteors in the open sky. There was no perceptible impression on the photographic plate in the trial made by Dr. Isaac Roberts last spring; but it has been thought desirable to repeat the observation, since the conditions will be somewhat more favourable in the coming season, owing to the increasing intensity of sunshine upon the meteors, which will make the brightness of the image of the stream upon the photographic plate about three times what it was last season.

It was from the first recognised that it falls short of being probable that even a great depth of bodies so small and so scattered will sufficiently impress the most delicate photographic plates we possess. But inasmuch as what is aimed at is not actually impossible, and as the gain to astronomy will be great if it is attained, it has been thought desirable to make preparation for another attack.

The ephemeris has been drawn up under the kind direction of Dr. Downing, Superintendent of the Nautical Almanac, and the computations have been made by Mr. Thomas Wright, of the National Almanac Office. The cost has been defrayed out of a grant made by the Royal Society.

Greenwich, midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.	Greenwich, midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.
1897.	h m s	° ′		1898.	h m s	° ′	
Dec. 24	14 10 54	S. 5 29	0·8995	Jan. 7	14 12 59	S. 5 21	0·8817
25	14 11 6	5 29	0·8983	8	14 13 5	5 20	0·8803
26	14 11 17	5 28	0·8970	9	14 13 10	5 19	0·8790
27	14 11 28	5 28	0·8958	10	14 13 15	5 18	0·8776
28	14 11 38	5 27	0·8946	11	14 13 19	5 17	0·8762
29	14 11 48	5 27	0·8933	12	14 13 23	5 15	0·8749
30	14 11 58	5 27	0·8921	13	14 13 26	5 14	0·8735
31	14 12 7	5 26	0·8908	14	14 13 29	5 13	0·8721
1898.				15	14 13 31	5 12	0·8707
Jan. 1	14 12 16	5 25	0·8895	16	14 13 33	5 10	0·8693
2	14 12 25	5 25	0·8882	17	14 13 34	5 9	0·8679
3	14 12 33	5 24	0·8869	18	14 13 35	5 7	0·8664
4	14 12 40	5 23	0·8856	19	14 13 35	5 5	0·8650
5	14 12 47	5 23	0·8843	20	14 13 34	5 4	0·8635
6	14 12 53	5 22	0·8830	21	14 13 33	5 2	0·8621

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Greenwich, midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.	Greenwich, midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.
1898.	h m s	° ′		1898.	h m s	° ′	
Jan. 22	14 13 32	S. 5 0	0·8607	Mar. 2	14 4 41	S. 3 3	0·8042
23	14 13 30	4 58	0·8593	3	14 4 14	2 59	0·8029
24	14 13 28	4 57	0·8578	4	14 3 47	2 55	0·8016
25	14 13 25	4 55	0·8564	5	14 3 19	2 50	0·8003
26	14 13 21	4 53	0·8549	6	14 2 50	2 46	0·7990
27	14 13 17	4 50	0·8535	7	14 2 21	2 42	0·7977
28	14 13 12	4 48	0·8520	8	14 1 52	2 37	0·7964
29	14 13 6	4 46	0·8505	9	14 1 22	2 33	0·7951
30	14 13 0	4 44	0·8490	10	14 0 51	2 28	0·7939
31	14 12 54	4 41	0·8476	11	14 0 20	2 24	0·7926
Feb. 1	14 12 47	4 39	0·8461	12	13 59 48	2 19	0·7914
2	14 12 39	4 37	0·8446	13	13 59 16	2 15	0·7902
3	14 12 30	4 34	0·8431	14	13 58 43	2 10	0·7890
4	14 12 21	4 31	0·8417	15	13 58 9	2 5	0·7879
5	14 12 11	4 29	0·8402	16	13 57 35	2 1	0·7867
6	14 12 1	4 26	0·8387	17	13 57 0	1 56	0·7856
7	14 11 50	4 23	0·8372	18	13 56 24	1 51	0·7845
8	14 11 38	4 21	0·8357	19	13 55 48	1 46	0·7834
9	14 11 26	4 18	0·8342	20	13 55 13	1 41	0·7823
10	14 11 13	4 15	0·8328	21	13 54 37	1 36	0·7813
11	14 11 0	4 12	0·8313	22	13 54 0	1 32	0·7802
12	14 10 47	4 9	0·8298	23	13 53 22	1 27	0·7792
13	14 10 32	4 6	0·8284	24	13 52 43	1 22	0·7782
14	14 10 16	4 2	0·8269	25	13 52 5	1 17	0·7773
15	14 10 0	3 59	0·8254	26	13 51 26	1 12	0·7763
16	14 9 43	3 56	0·8240	27	13 50 47	1 7	0·7754
17	14 9 26	3 52	0·8225	28	13 50 7	1 1	0·7745
18	14 9 8	3 49	0·8211	29	13 49 26	0 56	0·7736
19	14 8 49	3 45	0·8196	30	13 48 45	0 51	0·7727
20	14 8 30	3 42	0·8182	31	13 48 4	0 46	0·7719
21	14 8 10	3 38	0·8167	Apr. 1	13 47 23	0 41	0·7711
22	14 7 49	3 35	0·8153	2	13 46 41	0 36	0·7703
23	14 7 28	3 31	0·8139	3	13 45 59	0 31	0·7695
24	14 7 6	3 27	0·8125	4	13 45 17	0 26	0·7688
25	14 6 43	3 23	0·8111	5	13 44 34	0 21	0·7681
26	14 6 20	3 19	0·8097	6	13 43 51	0 16	0·7674
27	14 5 56	3 15	0·8083	7	13 43 8	0 10	0·7667
28	14 5 31	3 11	0·8070	8	13 42 25	0 5	0·7661
Mar. 1	14 5 6	3 7	0·8056				

A Spectroscopic Method for Determining the Second and Third Contacts during a Total Eclipse of the Sun. By William Shackleton, A.R.C.Sc.

The spectroscopic method by which the determination of all the contacts can be made, as given by Faye and Young in 1869, although capable of giving very accurate results, requires at the same time a moderately powerful spectroscope attached to a telescope, and also a great nicety of adjustment.

For many purposes at the actual time of eclipse the second and third contacts are more important than the others, so for the benefit of eclipse observers I give the following method by which these can be determined, being the one I employed during the total eclipse of 1896 August 9 in Novaya Zemlya, requiring no larger size of instrument than can be put into one's waistcoat pocket.

If at any time the Sun be looked at through a prism, a band of continuous spectrum will be seen, but in a total eclipse of the Sun, as the Moon advances, the Sun's disc will be gradually obscured until there is only a thin crescent left; if now this crescent be examined by means of the prism with the refracting edge parallel to the line joining the horns of the crescent, it will be seen that a slit is unnecessary, for eventually the remaining portion of the Sun's photosphere becomes so thin that the Fraunhofer groups make their appearance as curved lines. (This can be seen at any time by looking at the Moon with the same apparatus when a very thin crescent.)

A very convenient form of instrument to use is a small direct vision prism; the one I employed was an ordinary Maclean eyepiece or star spectroscope (kindly lent me by General A. de Gorloff), with the cylindrical lens removed. With such a small instrument the whole of the rapidly thinning crescent can be observed at once, and at length the continuous band of spectrum begins to get narrower, and bright arcs representing the spectrum of the chromosphere, corresponding in position to H_α, D_3, H_β, and H_γ, appear protruding at either side. It is now necessary to be on the alert, for these bright arcs grow rapidly in brightness and length, while the continuous band which they can be seen to cross grows correspondingly narrower with the waning photosphere, until at last with great rapidity it thins out to nothing, which moment of disappearance marks the time of second contact.

For the determination of the third contact it is necessary to observe the reverse phenomenon, *i.e.* the appearance of the continuous spectrum, crossing at right angles and in the middle of

their lengths the long chromospheric arcs seen near the end of totality; this point of re-appearance gives the time of third contact. Immediately preceding this, however, and in the same position, a great many short arcs parallel to the long chromospheric ones will flash in momentarily; these represent the spectrum of the reversing layer, and may be used as a warning that the photosphere will reappear within a few seconds after.

That this method is really capable of giving a fairly accurate result can be gathered from the "Preliminary Report on the

Ephemeris for Physical Observations of Jupiter,

Greenwich Noon	P	L−O	B	Apparent Diameter. Equat. 2a.	Defect.	Polar 2b.	d	w	B′
1897.	°	°	°	″	″	″	°	°	°
Dec. 10	25·114	51·782	−2·332	35·28	0·26	33·07	9·87	268·44	−2·49
12	25·096	52·029	2·348	35·47	·27	33·25	9·97	268·40	2·50
14	25·079	52·269	2·363	35·67	·27	33·43	10·06	268·36	2·52
16	25·062	52·499	2·378	35·86	·28	33·61	10·14	268·32	2·54
18	25·046	52·719	2·393	36·07	·28	33·81	10·20	268·28	2·55
20	25·030	52·930	2·408	36·28	·29	34·00	10·25	268·24	2·57
22	25·015	53·130	2·422	36·49	·29	34·20	10·30	268·20	2·58
24	25·000	53·320	2·436	36·70	·30	34·40	10·34	268·16	2·60
26	24·985	53·499	2·450	36·92	·30	34·60	10·37	268·12	2·61
28	24·971	53·668	2·464	37·13	0·30	34·81	10·38	268·08	2·63
30	24·958	53·825	2·477	37·36	0·31	35·02	10·39	268·05	2·64
1898.									
Jan. 1	24·945	53·971	2·490	37·58	·31	35·23	10·39	268·01	2·66
3	24·933	54·106	2·503	37·81	·31	35·44	10·38	267·97	2·67
5	24·922	54·229	2·516	38·04	·31	35·66	10·35	267·92	2·68
7	24·913	54·341	2·528	38·27	·31	35·87	10·31	267·88	2·70
9	24·904	54·440	2·540	38·51	·31	36·09	10·25	267·84	2·71
11	24·896	54·528	2·552	38·74	·31	36·32	10·19	267·79	2·72
13	24·889	54·603	2·564	38·97	0·30	36·54	10·12	267·74	2·73
15	24·883	54·666	2·575	39·21	·30	36·76	10·04	267·69	2·75
17	24·878	54·717	2·585	39·46	·30	36·98	9·92	267·63	2·76
19	24·875	54·755	2·595	39·70	·29	37·21	9·82	267·57	2·77
21	24·873	54·780	2·605	39·94	·29	37·44	9·69	267·51	2·78
23	24·872	54·793	2·614	40·18	·28	37·66	9·55	267·45	2·79
25	24·872	54·793	2·623	40·41	·27	37·88	9·40	267·38	2·80
27	24·872	54·780	2·632	40·65	·26	38·11	9·23	267·30	2·81
29	24·874	54·754	2·640	40·89	0·26	38·33	9·05	267·22	2·82
31	24·877	54·716	2·648	41·12	·25	38·55	8·86	267·14	2·82

Results obtained in Novaya Zemlya during the Eclipse of the Sun, 1896 August 9, with the Prismatic Camera." *

NOTE.—If all the contacts are to be determined, the first and fourth might be done by Young's method, and for estimating the second and third the same spectroscope could be employed with a very wide tangential slit at the points of disappearance and reappearance of the photosphere, or to give even a larger range of observation the slit might be removed altogether.

* *Phil. Trans.* vol. 189, p. 261. A. 1897.

1897–98. By A. C. D. Crommelin.

Greenwich Noon.	Longitude of Ⅱ's Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time	A − O	B
1897 Dec. 10	° 147·53	° 139·91	° +0·42	m 47·22	° 41·908	° −2·055
12	103·23	80·35	·43	46·97	42·060	2·061
14	58·95	20·81	·44	46·71	42·211	2·067
16	14·68	321·28	·45	46·45	42·362	2·073
18	330·42	261·76	·45	46·18	42·514	2·079
20	286·17	202·25	·46	45·92	42·665	2·085
22	241·93	142·75	·46	45·66	42·817	2·091
24	197·70	83·26	·46	45·39	42·967	2·097
26	153·48	23·78	·47	45·12	43·119	2·103
28	109·28	324·31	0·47	44·85	43·270	2·109
30	65·09	264·86	·47	44·59	43·421	2·115
1898 Jan. 1	20·90	205·41	·47	44·32	43·572	2·121
3	336·73	145·98	·47	44·06	43·723	2·127
5	292·57	86·56	·47	43·79	43·875	2·133
7	248·42	27·14	·46	43·52	44·026	2·139
9	204·28	327·74	·46	43·26	44·177	2·145
11	160·15	268·36	·45	42·99	44·328	2·151
13	116·04	208·98	0·45	42·74	44·479	2·156
15	71·93	149·61	·44	42·47	44·631	2·162
17	27·84	90·26	·43	42·22	44·781	2·167
19	343·76	30·92	·42	41·96	44·933	2·173
21	299·69	331·58	·41	41·71	45·084	2·178
23	255·63	272·26	·40	41·46	45·235	2·184
25	211·57	212·95	·38	41·22	45·387	2·190
27	167·53	153·65	·37	40·97	45·537	2·195
29	123·51	94·35	0·36	40·74	45·688	2·201
31	79·49	35·07	·34	40·50	45·840	2·206

Greenwich Noon.	P	L−O	B	Apparent Diameter. Equat. 2*a*.	Defect.	Polar 2*b*.	*d*	*w*	B′
1898.	°	°	°	″	″	″	°	°	°
Feb. 2	24·881	54·665	2·655	41·35	·24	38·77	8·66	267·05	2·83
4	24·887	54·602	2·662	41·58	·23	38·97	8·45	266·96	2·84
6	24·894	54·525	2·668	41·80	·22	39·18	8·23	266·87	2·85
8	24·902	54·437	2·674	42·02	·20	39·40	8·00	266·77	2·85
10	24·911	54·336	2·679	42·24	·19	39·60	7·75	266·67	2·86
12	24·921	54·224	2·683	42·45	·18	39·79	7·49	266·56	2·86
14	24·931	54·100	2·687	42·66	0·17	39·98	7·22	266·44	2·87
16	24·942	53·965	2·690	42·86	·16	40·18	6·93	266·31	2·87
18	24·954	53·818	2·693	43·05	·14	40·35	6·63	266·18	2·87
20	24·967	53·661	2·695	43·24	·13	40·53	6·31	266·03	2·87
22	24·981	53·493	2·696	43·42	·12	40·70	5·99	265·86	2·87
24	24·995	53·315	2·697	43·60	·11	40·87	5·66	265·66	2·88
26	25·010	53·128	2·698	43·76	·09	41·02	5·32	265·42	2·88
28	25·026	52·931	−2·698	43·91	·08	41·16	4·97	265·15	−2·88

The constants and notation are the same as those employed last year by Mr. Marth (*Monthly Notices*, vol. lvi. No. 10, p. 516). P. denotes the position angle of *Jupiter's* axis ; L−O+180° the jovicentric longitude of the Earth reckoned in the plane of the planet's equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere ; Λ−O+180° the jovicentric longitude of the Sun from the same point ; B, *B* the jovicentric latitudes of the Earth and Sun above the equator.

The formulæ for finding the distances of the tangents to the limbs in right ascension and declination and in other directions, and also the defect of illumination, were given by Mr. Marth in *Monthly Notices*, vol. xl. p. 490 ff, and in vol. xlv. p. 408.

The longitudes of *Jupiter's* central meridian are computed with unaltered values of the rates of rotation and of the zero meridians in the two adopted systems. The addition of the "Corr. for Phase" gives the longitudes of the meridians, which bisect the illuminated disc.

Greenwich Noon. 1898.	Longitude of ☿'s Central Meridian. 877°90 I.	870°27 II.	Corr. for Phase.	Light—time	A—O	B
	°	°	°	m	°	°
Feb. 2	35·47	335·80	·33	40·28	45·991	2·212
4	351·47	276·53	·31	40·06	46·141	2·218
6	307·48	217·28	·29	39·85	46·293	2·223
8	263·49	158·04	·28	39·64	46·444	2·229
10	219·52	98·80	·26	39 43	46·595	2·234
12	175·55	39·57	·24	39·24	46·746	2·240
14	131·59	340·35	0·23	39·05	46·897	2·246
16	87·64	281·14	·21	38 86	47·048	2·251
18	43·69	221·93	·19	38·69	47·199	2·257
20	359·75	162·73	·17	38·52	47·350	2·262
22	315·82	103·53	·16	38·36	47·501	2·268
24	271·89	44·34	·14	38·20	47·652	2·274
26	227·96	345·15	·12	38·06	47·803	2·279
28	184·04	285·97	+0·11	37·9	47·954	−2·285

The following example illustrates the method of finding the Greenwich mean times, at which the zero meridian of either system passes the middle of the illuminated disc:—

To find the passage of the zero meridian of System II. across the middle of the illuminated disc which occurs next after noon on 1898 January 1.

Longitude of central meridian corrected for Phase=205°·88
Defect from 360°=154°·12. Rotation in 48^h=1,740°·57. Hence interval after noon at which the passage takes place

$$=\frac{48^h \times 154{\cdot}12}{1740{\cdot}57}=4^h{\cdot}2502=4^h\ 15^m{\cdot}0$$

We can find subsequent passages by interpolating for the time required to rotate through 360°.

7 *Vanbrugh Park Road, Blackheath:*
1897 *November* 26.

Erratum in Mr. Tebbutt's paper, vol. lvii., p. 496.

Planet's App. R.A. on Dec. 1, opposite comp. star No. 1, *for* $4^h\ 41^m\ 52^s{\cdot}98$ *read* $4^h\ 41^m\ 52^s{\cdot}68$.

Errata in Prof. Safford's paper, vol. lvii.

Page 505, line 6, *for* $-0^s{\cdot}7$ *read* $+0^s{\cdot}7$.
„ „ „ 7, *for* $-0^s{\cdot}76$ *read* $+0^s{\cdot}76$.
„ „ „ 9 from bottom, *for* the standard chronographic transits *read* his own chronographic transits.
„ 506, line 12 from bottom, *for* $e'-e=0{\cdot}03$ *read* $e'-e=-0{\cdot}03$.
„ 507, lines 4, 5, 6 *omit* and W. Ellis to end of parag raph.
„ 508, line 9 from bottom, page 509, lines 5, 15, 19, and page 512, line 3, *for* H *Cephei* 51 *read* 51 H *Cephei*.
„ 509, lines 7 and 9 from bottom, *for* χ *read* x.
„ 511, line 3, *for* $0^s{\cdot}025$ *read* $0^s{\cdot}025$ sec δ.
„ „ „ 13, *for* $0^s{\cdot}019$ *read* $0^s{\cdot}019$ sec δ.
„ 512, „ 8, *for* $0^s{\cdot}006$ *read* $0^s{\cdot}006$ sec δ.
„ „ „ 9, *for* $0^s{\cdot}010$ or $0^s{\cdot}012$ *read* $0^s{\cdot}010$ sec δ or $0{\cdot}012$ sec d.
„ „ „ 15 from bottom, *for* $0^s{\cdot}026$ *read* $0^s{\cdot}026$ sec δ.
„ „ „ 13 from bottom, *for* $0^s{\cdot}042$, $0^s{\cdot}015$, and $0^s{\cdot}025$ *read* $0^s{\cdot}042$ sec δ, $0^s{\cdot}015$ sec δ, and $0^s{\cdot}025$ sec δ.

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